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Indian Standard

TEST CODE FOR GRAIN DRYERS

PART 1 SELECTION AND PREPARATION FOR TEST

(First Revision)

UDC 631·365·22 : 620·1

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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December 1984

Indian Standard

TEST CODE FOR GRAIN DRYERS

PART 1 SELECTION AND PREPARATION FOR TEST

(First Revision)

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TEST CODE FOR GRAIN DRYERS

PART 1 SELECTION AND PREPARATION FOR TEST

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part 1) (First Revision) was adopted by the Indian Standards Institution on 31 July 1984, after the draft finalized by the Agricultural Produce Processing Equipment Sectional Committee had been approved by the Agricultural and Food Products Division Council.

0.2 It is well known that if the crop having low moisture content is harvested, the shattering loss is more and if it is harvested at high moisture content, the storability and quality of the grain is very much reduced. In order to have a compromise between these two extreme situations, it is desirable to harvest the crop at a comparatively high moisture content and dry the grain to the required moisture content suitable for its storage and quality maintenance. Drying may be done in sun or by mechanical process. Sun drying is time consuming and a non-uniform process. Moreover in some grains, such as paddy, the quality of the grain is reduced if it is dried in the sun. It is, therefore, advisable to employ mechanical dryers. This would ensure the increased manufacture and use of the grain dryers by processing industry in the country.

0.3 Although the function of a grain dryer is to remove excess moisture from grain without loss of quality, the evaluation of its performance is very complex due to a wide variety of designs and sizes to cover the diverse requirements for drying capacity and cost. This code is, therefore, being issued to provide a procedure for evaluation of the performance of the dryers which should be of practical use to both the users and the manufacturers.

0.4 This standard is being issued in three parts. This part (Part 1) was first published in 1977 covering selection and preparation of dryers and drying materials to be used for testing. This has been revised to incorporate details of fuel and air as well as correction for evaporation rate. The other parts of the standard are as under:

Part 2 Methods of tests for continuous dryers

Part 3 Methods of tests for inside dryers

0.5 In preparation of this standard, besides deriving assistance from M/s SF India Limited, Calcutta, assistance has also been taken from the following:

BS 3986 : 1966 Methods of test for agricultural grain dryers. British Standards Institution.

ASAE S 248 : 2-1976 Construction and rating of equipment for drying farm crops. American Society of Agricultural Engineer.

0.6 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part 1) covers the method of selection and preparation of grain dryers and drying material for testing.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 8420-1977† shall apply.

3. AMBIENT CONDITIONS

3.1 The ambient conditions of temperature, pressure and relative humidity to which the results of the dryer test are to be corrected, shall be as under:

a) Temperature 25°C,
b) Pressure 1 013 kPa, and
c) Relative humidity 75 percent.

4. SELECTION OF DRYER

4.1 The dryer required to be tested may be either a proto-type or a production model. I case of a proto-type, the testing authority shall accept the sample as submitted by the manufacturer. In case of a production model, the dryer shall be selected randomly by the testing authority from the production series. The dryer shall be complete with its usual accessories and in a condition generally offered for sale.

---

*Rules for rounding off numerical values (*revised*).

†Glossary of terms relating to grain dryers.

4.2 The manufacturer shall supply the details of the specifications of the dryer consisting of the items listed in the specification sheet given in Appendix A, as well as any further data required to carry out the tests. The manufacturer shall also supply material flow diagram and all the relevant literature, such as operation and maintenance manual and parts catalogues, normally supplied along with the dryer.

4.3 The specification given by the manufacturer shall be checked and reported by the testing authority. The adequacy or otherwise of the literature and the manuals shall also be reported.

5. INSTALLATION OF DRYER FOR TESTING

5.1 At the time of test, the dryer shall be installed in such a way that the performance is not affected by the following:

a) Inadequacy of ancillary grain elevating and conveying equipment,

b) Unsuitability of the arrangements for allowing flow of air to and from the dryer, or

c) Any other factor.

5.2 A check shall be made by the manufacturer and the testing authorities that the dryer has been assembled and installed in accordance with the manufacturer's instructions. The dryer shall be fitted, for the purpose of the test, with such measuring devices as may be necessary, fitting of such devices to be carried out under the supervision of the testing authorities.

6. GENERAL TEST PROCEDURE

6.1 Site — The dryer shall be tested as installed for normal working but it is important for the purpose of testing that the site should have adjacent to its premises facilities suitable for storing, dampening and turning a sufficient quantity of grain for drying during the test.

6.2 Operation of the Dryer — During the test the dryer shall be adjusted by the testing authority in accordance with the manufacturer's published instructions. The testing authority shall make all measurements which form part of the test and take the prescribed samples of grain.

6.3 Supply of Grain -- The bulk of grain for the test shall meet the requirements given in Appendix B.

6.4 Indication of Damage — Samples of the grain used for the test shall be tested for germination capacity before and after drawing. Any depression of germination capacity which may occur during drying process shall be regarded as an indication of damage for food grains as well as seeds Although germination capacity is not directly relevant to the value of milling of grains, it is a more sensitive indicator of damage and is more easily measured than other properties. In case of wheat the baking properties should also be taken into consideration and appropriate tests before and after drying should be carried out to measure any loss in the baking properties. For oil bearing seeds, if the tests are carried out with the particular seed in question, the loss on evaporation in the dryer of the oil content shall be regarded as an indication of damage.

6.4.1 Each type of grain has a so-called critical temperature which shall not be exceeded if damage due to depression of germination and baking properties is to be avoided. The average permissible maximum temperature in the kernel at hot air drying is usually about 45°C. At moisture content under 20 percent however, approximately 5°C higher temperature is permissible, for example, wheat, barley, maize and oats have to have a lower temperature in the kernel as these grains do not stand as much heat. The critical temperature is somewhat less than the drying air temperature. For wheat with a moisture content of 20 percent, a kernel temperature of 57°C is permissible from baking point of view but only 55°C if the wheat is used as seed. At a moisture content of 15 percent, the values are 67°C and 62°C respectively.

6.5 Measurement of Dryer Holding Capacity — The amount of grain required to fill the dryer for proper operation shall be verified either when filling the dryer at the beginning of the test or when emptying it at the end.

7. MATERIAL AND EQUIPMENT

7.1 Fuel and Air — Fuel to be used in the test shall conform to the specification supplied by the manufacturer. In case such fuel is not easily available in market, the property of the fuel, to be used in the test, shall be informed to the manufacturer prior to test and shall be reported. The method for measurement of fuel and air is given in Appendix C and Appendix D respectively.

7.2 Measuring Instruments — The measuring instruments to be used shall be checked and calibrated prior to the measurements and shall be capable of taking the minimum scale and accuracy. The tolerance of the measuring instruments shall be reported.

APPENDIX A

(*Clause* 4.2)

SPECIFICATION SHEET

To be filled in by

Manufacturer Testing Authority

1. General

- a) Name of the manufacturer
- b) Address of the manufacturer
- c) Make of the dryer
- d) Model number of dryer
- e) Type of dryer

2. Blower

- a) Type
  - 1) Axial flow
  - 2) Radial flow
- b) Recommended speed
- c) Diameter of discharge port
- d) Diameter of impeller
- e) Number of rotating impeller vanes
- f) Blower rating
- g) Power requirement

3. Burner

- a) Type of fuel recommended
- b) Specification of fuel
- c) Burner rating
- d) Capacity of combustion chamber
- e) Area of fire-grade
- f) Temperature regulating system
- g) Normal spacing range between burner and blower

4. Motor

- a) Type
- b) Phase

To be Filled in by

Manufacturer Testing Authority

- c) Frequency in Hz
- d) Voltage
- e) Amperes at full load
- f) Rated speed
- g) Rated power
- h) Type of enclosure

5. Air Flow Guide Race

- a) Length and area of section
  - 1) Blower side
  - 2) Dryer side
- b) Connecting method
  - 1) Size of holes of wire net
  - 2) Holding capacity

7. Safety Measures

APPENDIX B

(*Clause* 6.3)

PROVISION AND SELECTION OF GRAIN

B-1. Sources of Supply and Type of Grain — The grain for test of continuous flow and batch dryer meant for drying foodgrains shall be milleable wheat, field harvested paddy, par-boiled paddy, maize or oil bearing grain. The grain as used shall not have received more than one drying treatment. The quantity used for a continuous flow dryer shall be 6 times the holding capacity of the dryer plus 4 times the rated hourly output of the dryer plus 10 percent calculated on the basis of dry grain at 15 percent moisture content. The quantity used for a batch dryer shall be 5 times the holding capacity of the dryer.

B-1.1 For the test of an in-silo dryer, the grain shall have received no previous drying treatment. It shall be pre-cleaned, if necessary. The mean moisture content of the damp grain used for the tests shall be as near as possible to 21 percent and no grain shall be admitted which has below 19 percent moisture content. Quantity of damp grain used shall be sufficient to fill the silo up to the level specified by the manufacturer.

B-2. Condition of Grain Before Use in the Test — For each 20 tonne of grains, intended for use in the test, a representative sample (*see* IS : 3714-1966*) shall be delivered to the testing authority in a sealed air tight container at least 3 weeks before the time arranged for the test. This bulk sample shall be sub-sampled by the testing authority and the following tests shall be carried out:

a) *Refractions* — In accordance with IS : 4333 (Part 1)-1967†.

b) *Moisture Determination* — In accordance with IS : 4333 (Part 2)-1967‡.

c) *Hectolitre Mass* — In accordance with IS : 4333 (Part 3)-1967§.

d) *Mass of 1 000 Grains* — In accordance with IS : 4333 (Part 4)-1968||.

e) *Germination Test* — In accordance with Appendix A of IS : 6894-1973¶, and

f) *Resistance to Heat Damage* — This shall be checked by the following procedure:

Samples of grain having moisture content to 21 ± 0·5 percent shall be heated in sealed aluminium cylinders (inside 9 mm, length 150 mm and wall thickness 0·15 mm) to temperatures of 59°C, 60°C, 61°C and 62°C. These temperatures shall be attained by a water-bath controlled to ± 0·1°C, before immersion of the tubes in it, and the samples heated for 65 minutes without drying at each of these temperatures. The germination capacity of the samples shall be subsequently determined and a curve drawn showing the relationship between grain temperature and germination capacity as a percentage of control and rejected if at 50 percent germination the curve is not reaching the temperature range of 59·5°C and 61·5°C.

B-3. Method of Dampening Grain — The quantity of water required to raise the moisture content of the grain to 21 percent to be used for the test shall be added to the grain by any convenient method under the supervision of the testing authority during the first of the 3 days immediately proceeding the test and grain subsequently mixed. The grain shall also be mixed twice on each of the following two days. Any necessary adjustment of moisture content after the initial dampening shall be made early on the second day.

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*Method for sampling of bigger size food grains.

†Method of analysis for foodgrains: Part 1 Refractions.

‡Method of analysis for foodgrains: Part 2 Moisture.

§Method of analysis for foodgrains: Part 3 Determination of hectolitre weight.

||Method of analysis for foodgrains: Part 4 Weight of 1 000 grains.

¶Specification for malting barley.

APPENDIX C

(*Clause* 7.1)

FUEL MEASUREMENT

C-1. Measurement of Energy Used in the Dryer — The energy measured shall be the electricity or fuel consumption of the prime mover(s) which activate the moving parts of the dryer and the fuel or electricity consumption of the source of heat. The consumption of electricity shall be normally measured by Watthour meter. The permissible error shall be ± 2 percent of the electricity used. The following are the suitable methods for measurement of fuel consumption.

C-1.1 For Gaseous Fuels

a) *Displacement Flow Meter* — When the consumption of gaseous fuel is measured by volume, the temperature and pressure of the gas shall be measured at the flow measuring point.

b) *Measurement of Reduction in Mass* — After the gas is supplied from a container difference in mass of the container from which the gas has been supplied could be used. Precautions shall be taken to ensure that the container is dry when measurements are taken.

C-1.2 For Liquid Fuels

a) Liquid flow meter like Rotameter, etc.

b) By expressing the difference in volume of the fuel supply tank. Measurement of the temperature and density of the fuel at the time of testing should also be taken at the flow measuring point.

C-1.3 For Solid Fuels — Measurement of the mass of the fuel shall be added to the combustion chamber. Level of fuel in the combustion chamber shall be maintained as near constant as practicable.

C-2. The Definition of Quality of Fuels — The heat value of a unit of electricity shall be taken as 3 600 K J. The gross heat value of gaseous and solid fuels and the gross heat value and specific gravity of liquid fuels shall be determined by analysis from a sample of the fuel used.

C-3. Measurement of Air Conditions to be Made During Test — The conditions of the ambient air and the exhaust air shall be determined from measurements made of the dry bulb temperature and the wet bulb or dew point temperature at the main air inlets and outlets of the dryer respectively. The temperature of the drying air shall be measured as near as practicable to the entry of the food grains to the dryer and the temperature of the air meant for cooling shall be measured at the cooling fan inlet. The barometric pressure has also to be measured.

C-3.1 From the above measurements, the values of relative humidity, absolute humidity can be arrived at by using standard Psychrometric chart and a Molliere diagram.

C-3.2 Variation in temperatures are liable to exist across a section of air stream and in order to obtain mean values the measuring sections shall be considered as being divided into equal areas and measurements necessary to derive the condition of air shall be made at the centre of each erea. Where automatic recording of temperature is not possible, sets of measurements shall be made at frequent intervals and average values for the test run should be indicated.

APPENDIX D

(*Clause* 7.1)

AIR DENSITY

D-1. The density of the dry air in an air/water mixture (D) and the density of the mixture (D_1), is to be calculated by the following:

$$D = \frac{0{\cdot}348\,(\,b - z\,)}{(\,T + 273\,)}\ \text{kg/m}^3$$

$$D_1 = \frac{0{\cdot}348\,(\,b - z\,)\,(\,1 - d_r\,)}{(\,T + 273\,)}\ \text{kg/m}^3$$

where

b = barometric pressure in mb,

z = vapour pressure of water in mb,

T = temperature in °C, and

d_r = relative density of water vapour compared with air at same temperature and pressure = 0·622.

D-1.1 In this Appendix the absolute value of density is not used directly and in normally small in comparison with b for all practical purposes:

$$\frac{D_c}{D_t} = \frac{b_c\,(\,T_t + 273\,)}{b_t\,(\,T_c + 273\,)}$$

Where the suffixes t and c relate to test and specified conditions respectively.

D-2. In a given system of fan and airways with constant fan speed and varying density it is assumed that the volume delivered is constant and the pressure is directly proportional to density thus the power required for the fan and the mass rate of flow of air are both directly proportional to the density.

D-2.1 The changes in air density due to temperature changes and changes in absolute humidity in a system shall be neglected. The effective density is thus the density at the inlet of the main fan. In calculating density, the temperature at the inlet of the main fan shall be used, that is, ambient temperature, hot air temperature or exhaust temperature according to the placing of the fan. The dry bulb temperature and the relative humidity of the ambient air shall be measured near the main air intake of the dryer, the measuring instruments being shielded from thermal radiation from the dryer. The weighted mean value of relative humidity over a period is that corresponding to a mean absolute humidity at mean dry bulb temperature of the air over that period.

D-2.2 With dryers with controlled fuel rate and with the main fan handling hot air, it will be necessary to calculate the approximate temperature at the fan by the following:

$$T_{ch} = \frac{b_t (T_{ch} + 273)}{b_c (T_{ch} + 273)} (T_{th} - T_{ta}) + 25^\circ C$$

where

T_{ch} = temperature of hot air corresponding to specified conditions, °C;

T_{th} = temperature of hot air on test;

T_{ta} = ambient temperature on test; and

b_c, b_t as given under **D-1.1**.

D-2.3 Where the main fan handles exhaust air, differences in density due to differences in exhaust temperature between test and specified conditions shall be neglected.

D-3. CORRECTIONS TO EVAPORATION RATE

D-3.1 *Method A* is based on the assumption that for dryers with beds of grains thick in relation to the mass flow of air through them, the exhaust relative humidity tends to be substantially controlled by the moisture content of the grain from which the air leaves. As the correction is made to evaporation rate assuming only slight changes in input and output moisture content it follows that $R_{ce} \simeq R_{te}$.

For continuous and batch dryers it is further assumed that the ratio of the increase of total heat of the drying air from ambient to exhaust states under test conditions to that under specified ambient conditions, is the same as the ratio of the rates of fuel consumption by the air heater under the two conditions; some account is, therefore, taken of losses but the contribution of the fan to air heating is neglected. For in-silo dryers, where the grain bed is intrinsically thick Method A always applies, the temperature rise is always small so that corrections are based on drying at constant total heat. For in-silo dryers the contribution of the fan heat to drying cannot be neglected and the calculations are included for the amount of drying that takes place even when the heaters are switched off.

D-3.2 *Method B* is based on the empirical formula proposed by Morris Thomas and applicable to dryers in which the exhaust relative humidity is not substantially controlled by the moisture content of the grain from which the air leaves.

If T_h = hot air temperature, °C

$$\text{Log}\left[\frac{\triangle M}{{G_m}^{0\cdot414}}\right] = 0\cdot020\,2\ T_h - 0\cdot701$$

where

$\triangle M$ = mean drying rate percent per hour (dry basis), and

G_m = relative mass air flow rate kg/hr/kg grain (dry basis).

D-3.2.1 In dryers with controlled hot air temperatures

$$T_{ch} = T_{th}$$

$$\text{Log}\left[\frac{\triangle M_c}{{G_{cm}}^{0\cdot414}}\right] = \text{Log}\left[\frac{\triangle M_t}{{G_{tm}}^{0\cdot414}}\right]$$

$$\left[\frac{\triangle M_c}{\triangle M_t}\right] = \left[\frac{G_{em}}{{G_{tm}}^{0\cdot414}}\right]$$

The amount of dry matter is constant from test to specified conditions:

$$\frac{E_c}{E_t} = \left[\frac{D_c}{D_t}\right]^{-0\cdot414}$$

D-3.2.2 In dryers with controlled fuel rate

$$T_{ch} = \frac{D_t}{D_c}\,(T_{th} - T_{ta}) + 25°\text{C}$$

$$\mathrm{Log}\left[\frac{\Delta M_{\mathrm{t}}}{G_{\mathrm{tm}}{}^{0\cdot414}}\right] = 0\cdot020\,2\ T_{\mathrm{th}} - 0\cdot701$$

$$\mathrm{Log}\left[\frac{\Delta M_{\mathrm{c}}}{G_{\mathrm{cm}}{}^{0\cdot414}}\right] = 0\cdot020\,2\ T_{\mathrm{ch}} - 0\cdot701$$

$$\mathrm{Log}\left[\frac{\Delta M_{\mathrm{t}}}{G_{\mathrm{tm}}{}^{0\cdot414}}\right] - \mathrm{Log}\left[\frac{\Delta M_{\mathrm{c}}}{G_{\mathrm{cm}}{}^{0\cdot414}}\right] = 0\cdot020\,2\ (\ T_{\mathrm{th}} - T_{\mathrm{ch}}\ )$$

$$\mathrm{Log}\left[\frac{\Delta M_{\mathrm{t}}}{\Delta M_{\mathrm{c}}} \times \left\{\frac{G_{\mathrm{cm}}}{G_{\mathrm{tm}}}\right\}^{0\cdot414}\right] = 0\cdot020\,2\ (\ T_{\mathrm{th}} - T_{\mathrm{ch}}\ )$$

$$\mathrm{Log}\left[\frac{E_{\mathrm{t}}}{E_{\mathrm{c}}} \times \left\{\frac{D_{\mathrm{c}}}{D_{\mathrm{t}}}\right\}^{0\cdot414}\right] = 0\cdot020\,2\ (\ T_{\mathrm{th}} - T_{\mathrm{ch}}\ )$$

D-3.3 Summary of Symbols Used — Suffixes used with more than one symbol conform to the following pattern:

c = value corresponding to specified ambient conditions

t = value corresponding to ambient conditions on test

a = ambient; e = exhaust; h = hot air (inlet)

Example:

T_{th} = hot air (inlet) temperature on test.

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[*Page* 9, *clause* B-2(a)] — Substitute 'IS 4333 (Part 1) :1977' *for* 'IS 4333 (Part 1) : 1967' and the corresponding title in the footnote as 'Method of analysis for foodgrains : Part 1 Refrection (*first revision*)'.

[*Page* 9, *clause* B-2(e)] — Substitute 'IS 6894 : 1993' *for* 'IS 6894 : 1973' and the corresponding title in the footnote as 'Specification for malting barley (*first revision*)'.

(FAD 51)

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